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LABORATORY MANUAL

FOR THE COURSE IN

ELEMENTARY AND ECONOMIC

ENTOMOLOGY

AT THE

UNIVERSITY OF CALIFORNIA

—BY—

C. W. WOODWORTH



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ELEMENTARY AND ECONOMIC

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UNIVERSITY OF CALIFORNIA

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FIRST WEEK.



NEEDED.* A number of grasshoppers.

FIRST HOUR. Draw one of the legs, naming the parts as follows: Coxa, trochanter, femur, tibia, tarsus (three-jointed). Describe the nature of the union between each of these parts. Compare each of these parts in the three pairs of legs, and note particularly: (*a*) Strengthening ridges, (*b*) modifications of the surface for the attachment of muscles, (*c*) guidepieces at the joints, (*d*) position and use of spines, (*e*) pads on the feet—the one at the end is called the pulvillus,—(*f*) claws on the feet—ungues. Note the number of joints in the antenna, the two basal ones (scape and pedicel) somewhat different from the remaining part—flagellum. Indicate the character of the union between these parts. Examine the eyes and the simple eyes—ocelli, describing their shape and position.

SECOND HOUR. Remove the head and pin it against the cork holder. Observe the palpi. Note the number of joints in each pair. Observe the lips above or in front—labrum, on the sides—galeae, and below—labium. Draw the whole labium indicating the mentum, ligula, palpi and the lobes—lips proper. Remove the labium, exposing the maxillæ. Draw one of these, naming the parts as follows: Cardo, stipes, palpifer, palpus, galea, lacinea. Examine the large jaws—mandibles, beyond the maxillæ, and the small basal piece, and also the clypeus to which the labrum is attached.

THIRD HOUR. Insert a blunt pin into the hind end of the insect, pushing it forward until it comes against the front of the head, stretching the neck well out. Observe now the parts of which the head is composed, and indicate the relation of these parts to the appendages. Attempt to trace by semi-diagrammatic drawings the relation between labium and maxillæ and between all the appendages of the head and legs.

*The following material is needed throughout the course:—

Magnifier. A Coddington or other lens of about a half-inch focus.

Cyanide bottle. A small lump of cyanide of potash cemented to the bottom of an eight ounce salt-mouth bottle in plaster of Paris.

Pins. Klæger insect pins Nos. 1, 3, and 5 are recommended, but ordinary pins do for dissecting.

Cork holder. A wine or other large cork to pin the insect to while studying.

SECOND WEEK.

NEEDED. A number of grasshoppers.

FIRST HOUR. Examine the front wing, noticing the strong vein extending to the base (subcostal vein), and also the other strong vein (median vein), which, with the subcostal vein, divides the wing into three more or less equal parts. Notice further the costal vein, independent vein, and submedian vein within these areas. Draw an outline of the wing, naming these parts—costal, median, and internal areas, and sketch in roughly the veins and their branches. Now on a larger scale draw the base of the wing, indicating accurately the number and origin of each vein in this region.

SECOND HOUR. Draw one of the hind wings in the same way as directed above for the front wings, marking out very carefully the homology of the veins with those of the front wings.

THIRD HOUR. The three segments of the thorax are called the pro- meso- and metathorax, and the same prefixes are used to designate the parts of each of these segments. Above they are called tergum or notum, the sides pluræ, and beneath sternum. The notum is divided into four tergites (præscutum, scutum, scutellum, and postscutellum), the pleuræ into two pleurites (episternum and epimeron), and the sternum of each segment contains but a single sternite. Describe or draw these parts as they appear on the grasshopper, noting particularly: (*a*) The great size of the pronotum, (*b*) the absence of the præepimeron, (*c*) the small size of the prosternum, and (*d*) the dovetailing between the sternites of the second and third thoracic and first abdominal segments.

THIRD WEEK.

NEEDED. A number of grasshoppers, including both sexes.

FIRST HOUR. Study the union of the wing with the body. Make a drawing both from above and below. Examine the wing in all positions, and describe the action of the hinge parts.

SECOND HOUR. Draw the first two abdominal segments, making out carefully the division between the thorax and abdomen. Draw on a larger scale the ear. Notice the chitinous border of the tympanum, and note the shape and position of the lateral and central processes of the tympanum. Notice the spiracle near the front edge of the ear, and note the position of all the spiracles on the insect's body.

THIRD HOUR. Male. Draw carefully the end of the abdomen as seen from the side, numbering all the parts so as to indicate the segments to which they appertain. Now, grasping the abdomen near the thorax, slowly compress it until the organs are widely spread, and draw again. Note the cerci, the three anal flaps and the clasping organ. Female. Draw twice from the side, as directed above, noting the cerci, the anal flaps, the four valves of the ovipositor, the egg guides and the extensile glands between the eighth and ninth segments below. Try to homologize the parts in the two sexes.

FOURTH WEEK.

NEEDED. A sauce dish. Some pasteboard cut so as to lay in the bottom of the dish. A sharp-pointed knife or small sharp-pointed scissors. A number of grasshoppers.

FIRST HOUR. With scissors or knife rip the insect open along the side from end to end, then putting a pin through the head and another through the harder part of the hind end of the body, stretch the insect out full length on a piece of pasteboard, putting in the pins very obliquely. With other pins spread out the body, exposing all the internal structure, and place the whole under water in the sauce dish. Observe the digestive tract, the air sacs, the sexual organs in the abdomen, the tracheæ in all parts of the body, and, pulling the alimentary tract to one side, notice the heart. Notice further the nervous system along the sternum and the muscles of the thorax. Carefully dissect out the digestive system, noting the pharynx, with the salivary glands, the œsophagus, the crop, with the cæca, the stomach, the ilium, with the Malpighian tubes, the colon, and the rectum, with the rectal glands.

SECOND HOUR. Dissect out the sexual organs of both sexes, describing their structure. Describe the size and position of the principal air sacs. Dissect out and describe the prominent parts of the nervous system in the body.

THIRD HOUR. Carefully separate the head from the body, and cut the wall of the head, beginning at the mouth and running back of the eyes, removing the back part. Now pin the head to pasteboard, and, putting it into water, make out carefully the brain, drawing and describing it.

FIFTH WEEK.

NEEDED. A number of rather large-sized beetles.

FIRST HOUR. Dissect out and draw the mouth parts of at least two species. Compare with each other and with those of the grasshopper. Consult the introduction to LeConte and Horn's Classification of Coleoptera.

SECOND HOUR. Draw the under side of the thorax of at least two species, naming all the parts, and compare them with the corresponding parts of the grasshopper.

THIRD HOUR. Describe the beetle according to the following outline:—

Whole insect	}	ACCORDING TO	{	Size
Head				Color
Appendages				Markings
Thorax				Shape
Appendages				Sculpture
Abdomen				

SIXTH WEEK.

NEEDED. Dissecting apparatus as for the fourth week. A number of butterflies or moths and caterpillars.

FIRST HOUR. Carefully study and describe the mouth parts. Draw the venation of both front and hind wings of one or more species. Indicate the homology between the veins in the wings of these insects and those of grasshoppers. For the peculiar terms used in this order, compare the introduction of Morris' Synopsis of Lepidoptera.

SECOND HOUR. Denude the thorax of its scales, study and draw, naming the parts exposed. (The scales are much more readily removed from moths than from butterflies.)

THIRD HOUR. Describe the peculiarities of external structure of a caterpillar. If the caterpillar is hairy, remove the hairs with the scissors. Lay open the body as directed in the fourth week, and compare the internal structures with those of the grasshopper.

SEVENTH WEEK.

NEEDED. A few slides and covers and a number of wasps.

FIRST HOUR. Make careful dissections and drawings of the mouth parts, comparing them with these already studied. For this study, the labium and maxilla is best seen mounted in water on a slide. The part should be dissected out and placed upon a small drop of water on the center of the slide, and the cover glass laid on. Only enough water to fill the space between the cover and the slide is wanted.

SECOND HOUR. Make careful drawings of the wings, making out the homology of those so far studied, and also naming the veins according to the peculiar nomenclature used in this order. Compare the introduction to Cresson's Synopsis of Hymenoptera.

THIRD HOUR. Study the thorax drawing, and name the parts.

ELECTIVE WORK.—Description.

Weeks twelve to sixteen, either wholly or in part, may be devoted to writing descriptions of insects. One insect should be described each week. The descriptions should be full and accurate, and consist of:—

1. Name.
2. Short description consisting of: (*a*) Size, (*b*) general color, (*c*) striking peculiarities.
3. Full description, beginning at the head and taking up each part in detail.
4. Notes on habitat, etc.
5. Number of specimens studied.

Before writing the description, carefully read at least two recent descriptions of closely related insects, and use the same nomenclature. It is well to illustrate by figures, but the description should be complete in itself, and not depend upon the figures. The important thing in writing a description is to distinguish the things which characterize the insect as a species from those, on the one hand, which are common property of the whole group, and, on the other, are peculiar to the specimen or variety. This becomes much more easy to do when a large number of specimens are studied, both of the species and of related species. In collecting, therefore, for this purpose take, whenever possible, many of the same kind. In writing a description it often becomes necessary to mutilate a specimen. The description should be accompanied, however, with at least one perfect specimen.

EIGHTH WEEK

In this and the three succeeding weeks twelve species are to be determined as nearly as may be with the available literature. This twelve must include at least one of each of the following orders: Hymenoptera, Lepidoptera, Diptera, Coleoptera, Hemiptera and Orthoptera. Make notes and drawings freely while making the determinations, and note particularly the publications used and the results obtained.

HYMENOPTERA. Cresson's Synopsis is the basis for determinations in this order. Consult also manuscript synopses of particular groups. For a reference to the described species compare Cresson's Catalogue of the species of Hymenoptera.

LEPIDOPTERA. Use Morris' Synopsis of Lepidoptera for the groups represented therein. Consult Smith's List of Lepidoptera and also manuscript synopses and lists.

DIPTERA. Williston's Synopsis of Diptera. For the genera of Orthorapha not in Williston see manuscript synopsis. For Cyclorapha use Schiner's Fauna Austrica. For species consult Osten Sacken's Catalogue of Diptera and manuscript additions.

NEUROPTERA. Use Hagen's Synopsis of Neuroptera.

COLEOPTERA. For genera use LeConte and Horn's Classification of Coleoptera and for species compare Henshaw's Lists of Synopses and his Checklist.

HEMIPTERA AND PHYSOPODA. Use synopsis in Comstock's Introduction to Entomology and also manuscript synopses and lists. Compare Uhler's Checklist of Heteroptera and manuscript list of Homoptera.

ORTHOPTERA. Use synopsis in Comstock's Introduction to Entomology and manuscript synopses and lists.

PSEUDONEUROPTERA. Use Hagen's Synopsis of Neuroptera.

THRYSANURA. Use synopsis in Comstock's Introduction to Entomology.

ELECTIVE WORK.—Determination.

The twelfth to sixteenth weeks may be partly or wholly used for further determinations. It is recommended that the student devote himself to as small a group as possible. Three species should represent each week's work.

NINTH WEEK.

Three specimens of insects should be determined this week. For directions see under eighth week.

ELECTIVE WORK.—Physiology.

If this work is elected, the whole of one of the following groups must be done:—

GROUP I. Walking. Needed: (a) For blue printing: solution of citrate of iron and ammonia, one part to four of water; solution of red prussate of potash, one part to six of water; dish for sensitizing bath, some plain paper not too highly sized. (b) For tracings: A candle, some small panes of glass; (c) for loading: a little wax or soft paraffin, some shot of rather large size; (d) for experimenting with, a number of insects of the same species and of rather large size.

TWELFTH WEEK. Sensitize some paper by wetting one side of it with a mixture of equal parts of the above solutions and drying. This should all be done in the dark room. Blacken a sheet of glass by holding it over the burning candle. Lay the blackened glass on the table, and cause an insect to walk over it, and take a blue print copy of the tracing thus obtained. Illustrate by diagramatic sketches the method of walking as made out by a study of the tracings. Fasten a blue print of the tracing into the book.

THIRTEENTH WEEK. Repeat the above, but with mutilated specimens, showing the method of walking with five and four legs instead of the normal number.

FOURTEENTH WEEK. Melt a little of the wax or paraffin and place a drop on one end or side of the insect experimented with, and imbed in it one or more shot so as to weigh the insect down on that side or end. Obtain tracings as above and compare the results with normal walking. Repeat once or twice with the load at different places.

FIFTEENTH WEEK. Obtain tracings of the same species on inclined surfaces and compare with the loaded and with the normal walking.

SIXTEENTH WEEK. Obtain tracings showing a change in locomotion due to a sensation, as a touch or sound, and compare the tracings before and after the change as well as the transition.

GROUP II. Flight. Needed: A pair of small sharp-pointed scissors, some wax or soft paraffin, some small shot, India ink, a small camel's hair pencil, a vial of chloroform, a number of house flies.

TWELFTH WEEK. Cut off an equal amount from both wings of a fly, and, allowing it to escape with a normal fly, note the effect of the mutilation. Repeat two or three times, clipping off different relative amounts, but always the same on the two sides. Repeat two or three times, taking parts off from the back edge only.

THIRTEENTH WEEK. Repeat the above experiments, mutilating only one side, and note results.



TENTH WEEK.

Three species of insects should be determined this week. For directions see under sixth week.

ELECTIVE WORK.—Physiology (con.)

FOURTEENTH WEEK. Observe and note the effect of loading the body with shot and the tip of one and both wings with wax or paraffin.

FIFTEENTH WEEK. Remove one and both halteres and note the result. Darken the ocelli with India ink, and note results. Darken also one and both eyes, and both eyes and ocelli. Note particularly the significance of these results.

SIXTEENTH WEEK. Slightly chloroform a number of flies and compare their flight with the normal, and also observe the effect of placing flies a short time in a cyanide bottle. Note particularly the significance of these results as compared with the preceding experiments.

GROUP III. Sensations. Needed: Blue printing and tracing materials as in group one, but larger-sized sheets, at least twelve inches square. A set of blocks $1 \times 1 \times \frac{1}{4}$ inches in size—twelve white, twelve black, six red, six blue, six yellow and six green. A box divided into six equal sections by partial partitions, with a set of glass covers for these partitions—six clear, six black, one red, one yellow, one blue and one green. A musical instrument. A set of vials containing different odors. A quantity of insects of various kinds.

TWELFTH WEEK. Blacken a sheet of glass and arrange the black and white blocks on it to form a labyrinth, so that an insect set in the middle cannot see out. Set in a light where the blocks will cast distinct shadows and liberate an insect in the center. The tracing it makes indicates to some extent its sight perception. After the tracing is made mark the outline of the shadows with a pin and also the outlines of the blocks, writing as well the color of each. Now take a blue print of the tracings and note the significance of the various parts.

THIRTEENTH WEEK. Repeat the above, but with the labyrinth composed of blocks of all colors to determine the relative color perception.

FOURTEENTH WEEK. Arrange the colored plates over the sections of the box and liberate a number of insects, first in one and then in another, and after a short time note in what compartments they are to be found, and thus determine for each insect its color preference.

FIFTEENTH WEEK. Place an insect where it can be carefully watched, and then sound different tones on the musical instrument and note any evidence of sound perception. Determine for those evincing this perception the pitch producing the most effect and see if the instrument produces notes in either direction beyond their power of perception.

SIXTEENTH WEEK. Cover the sections of the box with all black or all clear glass, according to the nature of the insects experimented with, and place in each an open vial containing an odor. Now by liberating a number of insects, first in one and then in another, their odor preference may be determined.

ELEVENTH WEEK.

Three species of insects should be determined this week. For directions see under eighth week.

ELECTIVE WORK—Physiology (con.)

GROUP IV. Effect of temperature. Needed: A number of thermometers. A box with glass cover. A watch or metronome. A musical instrument. A number of small potted plants and lamp globes. Insects, some with a visible heart, some with evident respiratory movements, some with sound perception, and some plant lice.

TWELFTH WEEK. Carefully note the temperature and count the heart beat. Place the insect and the thermometer in the box and set upon the stove. After raising the temperature about 10 degrees F. remove and wait till the thermometer begins to fall, and count again the heart beat. Repeat, raising the temperature about ten degrees at a time until it has become uncomfortable for the insect. If time remains, continue the observations while the box is cooling at each temperature before observed.

THIRTEENTH WEEK. Repeat the above, counting the respiration beats instead of those of the heart.

FOURTEENTH WEEK. Repeat the above, counting the time required by a plant louse to walk over a certain distance under the different temperatures.

FIFTEENTH WEEK. Try to discover if there is any difference due to the temperature in (a) acuteness of sound perception, (b) pitch of best perception, and (c) range of sound perception.

SIXTEENTH WEEK. The work of this week should be started at least six weeks before the end of the term. Make a number of breeding cages, as directed under Life History Work, using, if possible rooted plants. Put in each a thermometer and a newly born plant louse. One cage should be placed out-of-doors, another in a living room, and a third, if possible, in a still warmer place. It would be well to have two in each place to allow for accidents. The thermometers should be read three times a day as regularly as possible, and the insects examined. At the end of six weeks the relative condition of each cage should be carefully noted.

TWELFTH WEEK.

The work of this and the following weeks is to be selected from the work laid down as elective work in this manual. If work in physiology or morphology is elected all five weeks must be devoted to a single group in one of these subjects. Other work may be taken in any combination of one-week units. The directions for elective work will be found as follows:—

- Description under week seven;
- Determination under week eight;
- Life history under week twelve;
- Field work under week thirteen;
- Physiology under weeks nine to eleven;
- Morphology under weeks fourteen to sixteen.

ELECTIVE WORK.—Life History.

The laboratory work of weeks twelve to sixteen may be represented by investigations upon the life histories of insects. From the nature of this work it cannot generally all be done during these weeks, but should be begun earlier. Three transformations will be considered equivalent to a week's work. Each stage should be represented by a short descriptive note or sketch and by a properly mounted specimen. Thus four stages of one insect would represent a week's work, as would two stages of each of three insects. Parasites will be counted as though they were stages of the insect studied.

Eggs may be hatched by placing them in a dry vial, stoppered and labeled, or they may be at once placed in breeding cages, as described below.

Larvæ and nymphs, if vegetable feeders, may be kept in a breeding cage made as follows: A twig of the food plant is placed in a flowerpot filled with moist sand and covered by a lantern or lamp globe which is closed above with a piece of cloth tied on. If the larvæ are young it may be necessary to renew the food from time to time. Another method is to enclose the insect in a cheese-cloth sleeve tied over the twig upon which it feeds. A third way is to watch the insect as it occurs in nature, being very careful that there is no mistake in identity. Carnivorous forms must be supplied with their appropriate food, but practically the same method may be used.

Pupæ are best kept in tight boxes, which should be of a size sufficient to allow the full expansion of the wings.

Adults can often be made to lay their eggs, sometimes by simply confining the females in a box; generally, however, it is best to confine her in a breeding cage with the appropriate food for her young.



THIRTEENTH WEEK.

The work of this week is elective. For directions see under twelfth week.

ELECTIVE WORK.—Field Work.

NEEDED. Slides, covers, glycerine jelly, alcohol, oil of cloves, and balsam.

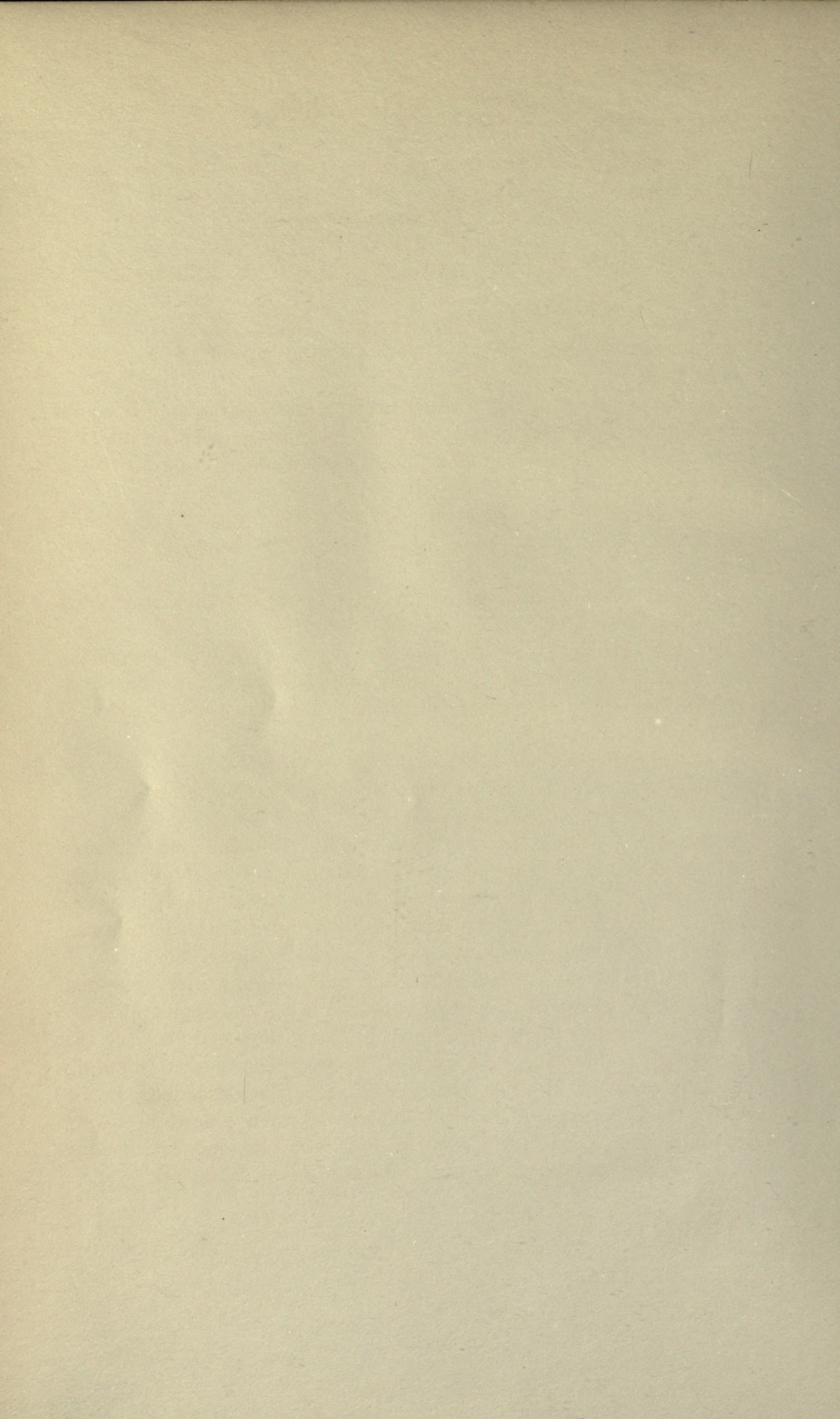
TWELFTH WEEK. In the field: Search for a plant affected with large scale insects. Note the general appearance of the affected plant. Note the abundance and distribution of the scale insects on the plant. Look for evidences of parasitism and work of predaceous insects, collect any specimens that may show such work and also twigs containing normal scales. In the laboratory: Look for eggs and young and continue the search for parasites. Mount the eggs and young if found, in glycerine jelly, as follows: With the point of a penknife pick out a piece of jelly about one sixteenth of an inch in diameter and place on the center of a slide. Upon this place the insect to be mounted and lay on the cover glass and gently heat until the jelly becomes fluid. Examine under the microscope and describe briefly. Determine the species by U. S. Agr. Report for 1880.

THIRTEENTH WEEK. In the field: Search for a plant affected with small whitish scales and do as directed above for the large scales. In the laboratory: Mount specimens of the insects from beneath the scales in glycerine jelly, as directed above, and in Canada balsam, as follow: Place the insects in alcohol five minutes and then in oil of cloves about the same length of time. Now put a small drop of balsam on the center of the slide and the insect upon it, and cover. Warm gently as before. Determine the species by U. S. Agr. Report for 1880 and Cornell University Report for 1882.

FOURTEENTH WEEK. In the field: Turn over a piece of sod with a spade and carefully pick the earth to pieces searching for root-feeding larvæ. Look for and note any evidences of injury, and collect specimens. In the laboratory: Determine, as nearly as possible from books and the collection, the group of the insects found and make a brief descriptive note of each. Properly mount and label each specimen.

FIFTEENTH WEEK. In the field: Look for a tree or fallen log affected with borers; collect specimens of the insects and of their work. In the laboratory: Determine, as nearly as possible, the insects collected. Make a descriptive note of the insects and sketches showing their work. Properly mount and label the material collected.

SIXTEENTH WEEK. In the field: Look for a leaf-eating or fruit-eating insect and collect specimens. In the laboratory: Determine, mount and note as above.



FOURTEENTH WEEK.

The work of this week is elective. For directions see under twelfth week.

ELECTIVE WORK.—Morphology.

If this subject is elected the whole of one of the following groups must be done:—

GROUP I. Venation of grasshopper wings. Needed: Slides, large covers, alcohol, oil of cloves, Canada balsam, a number of grasshoppers.

Mount all the wings of at least twelve grasshoppers in balsam, as directed under field work, being very careful to note on each slide the source of each wing, also mount and label the specimens from which the wings were taken.

THIRTEENTH WEEK. Make careful drawings of the front and hind wings, showing the principal veins in the two most different species.

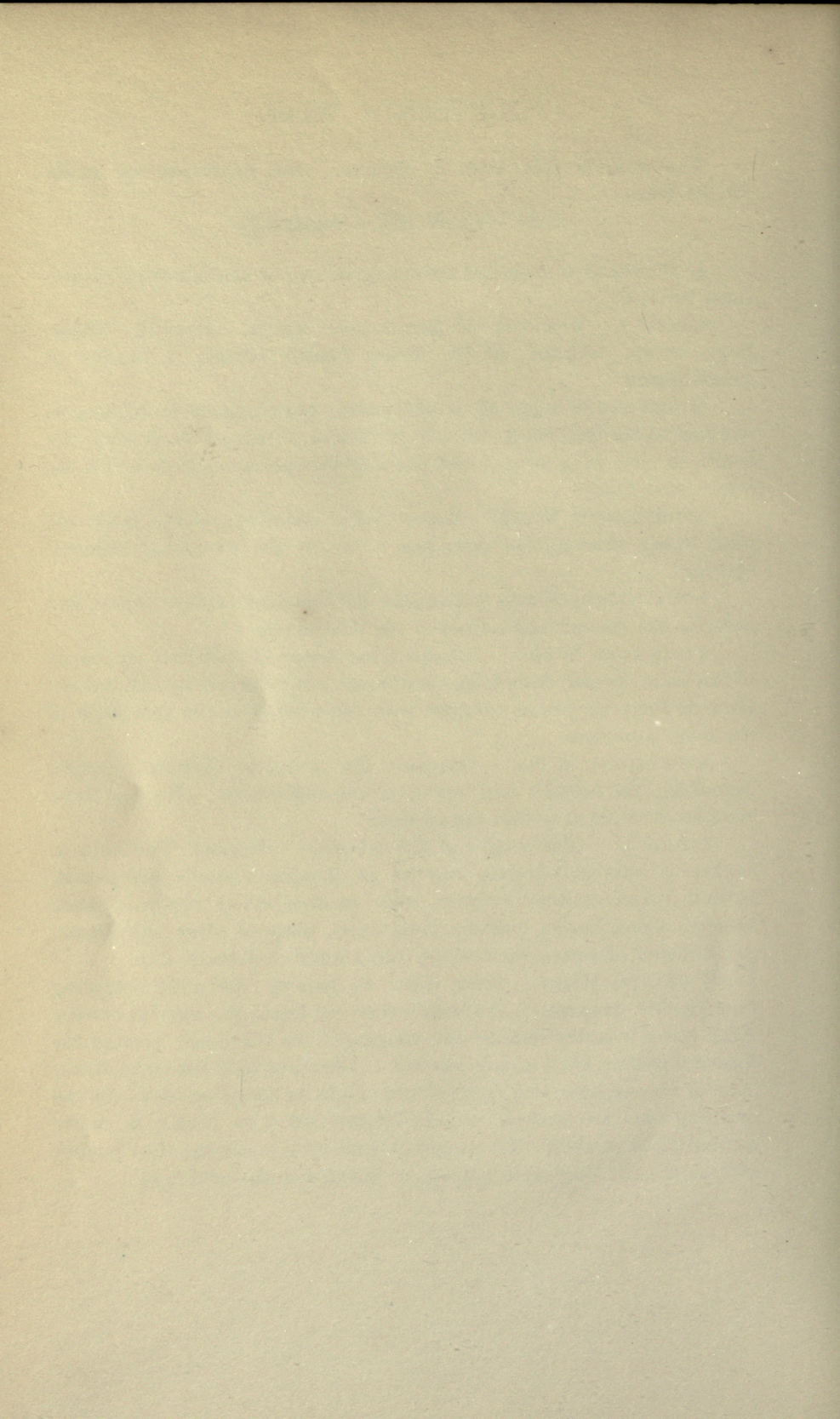
FOURTEENTH WEEK. Compare the two sides of each insect and describe the amount and nature of the differences.

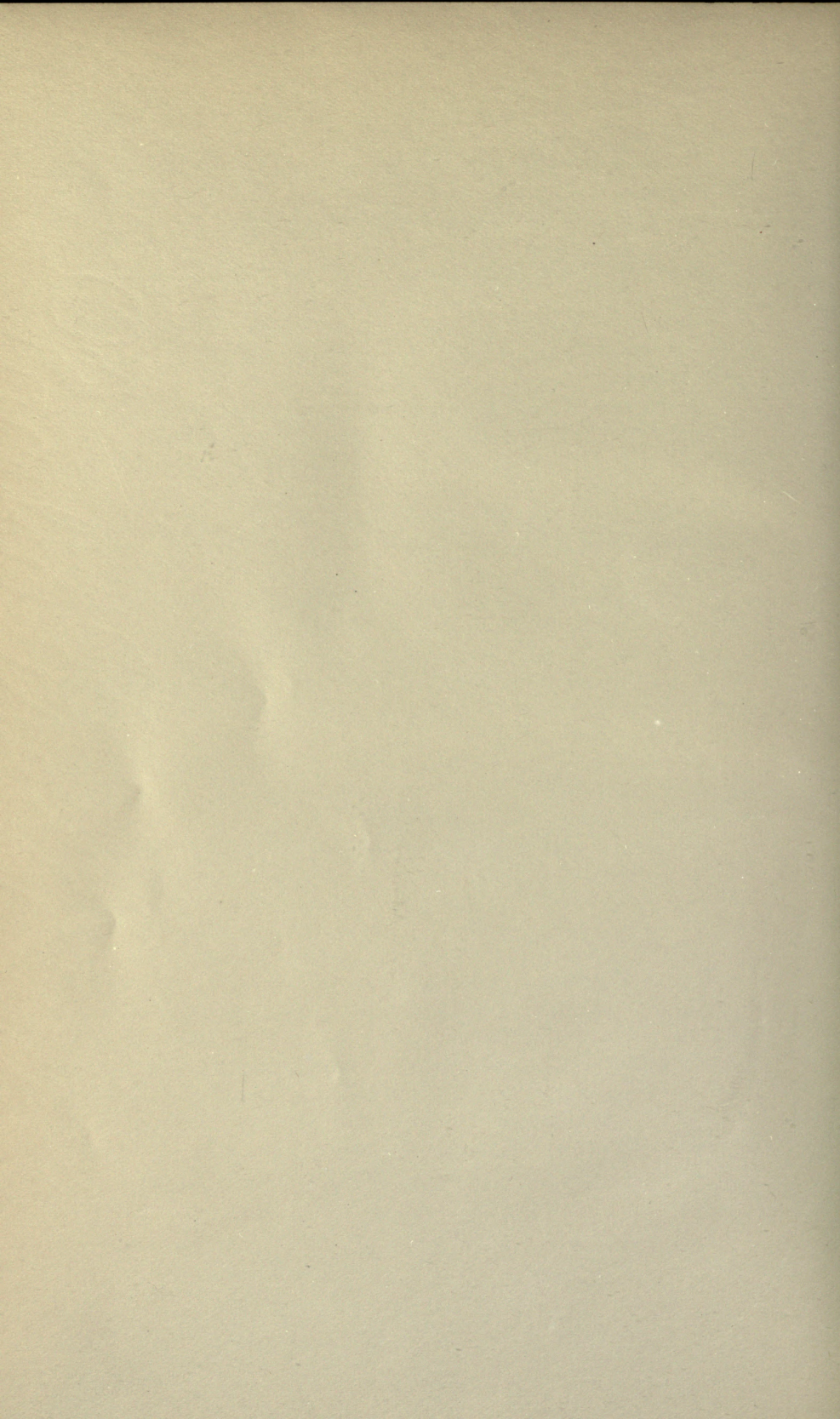
FIFTEENTH WEEK. Compare the wings of different specimens of the same species, describing the amount and nature of the differences. How do these variations compare with those found in the two sides of the same specimen?

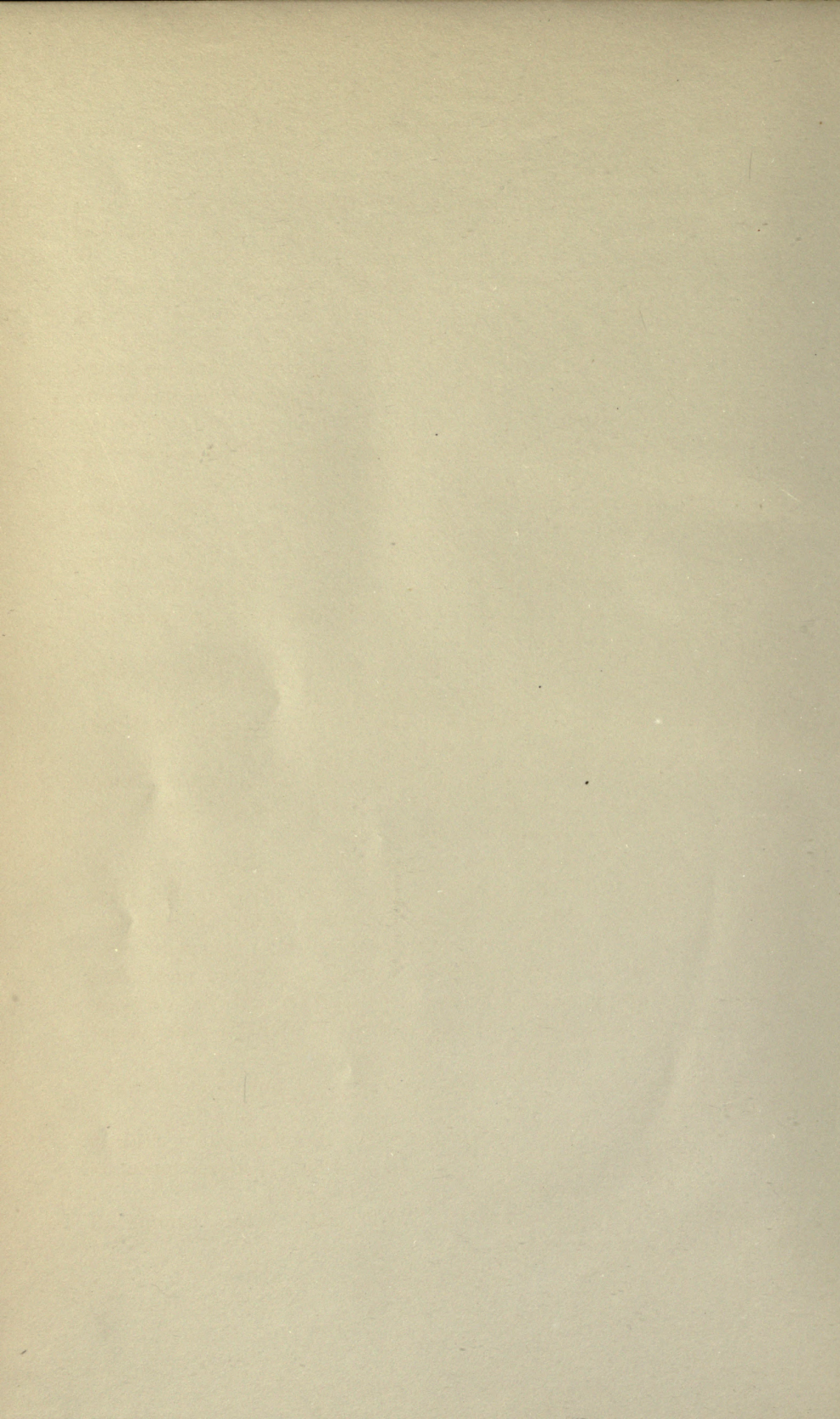
SIXTEENTH WEEK. Compare the wings of different species, describing the amount and nature of the differences. How do these compare with those within the species?

GROUP II. The tongue of the house fly. Needed: Test tube or beaker, a number of vials, needles in handles, camel's-hair pencil, alcohol, borax carmine solution, acid alcohol, oil of cloves, Canada balsam, slides, covers, paraffin bath, label, plate of glass, microtome, Schällibaum's fixative, microscope, and a number of house flies.

TWELFTH WEEK. Heat water to boiling, and after removing from the fire, drop into it the freshly-removed heads of a number of flies. After three minutes remove the tongues from the head, leaving the former a half an hour in 50% alcohol. They are then placed in strong alcohol for one hour and then left over night in borax carmine. In the morning they are washed in acid alcohol and then placed in strong alcohol till next week. Treat some others in hot water and then remove and mount the tongues in balsam, as directed under field work.







FIFTEENTH WEEK.

The work of this week is elective. For directions see under twelfth week.

ELECTIVE WORK.—Morphology (con.)

THIRTEENTH WEEK. The tongues stained last week are removed to fresh strong alcohol a few minutes, then to oil of cloves about two minutes, until they have become uniformly somewhat clear. They are now put into barely melted soft paraffin (50° C.) for one-half hour, then for one hour into harder (55° C.) Ladle out onto a wet cold plate of glass, so as to form thick drops with a tongue in the middle of each. After they are thoroughly cool trim into rectangular blocks and fasten one by means of a hot knife blade to the object holder of the microtome in such a position as to cut cross sections. Cut as thin as possible, adjusting the temperature of the room to the hardness and thickness of the section, so that, while the sections will not wrinkle, they will stick together and form a perfect ribbon. Keep the order of every section very carefully should the ribbon break. Mount as follows: Paint a thin layer of Schällibaum's fixative on a slide. Arrange the sections in the order cut, using two slides if one is not enough. Place in the oven of the bath at 55° C. five minutes. Wash while hot with turpentine and apply the balsam and cover at once.

FOURTEENTH WEEK. Cut and mount two more sets of section longitudinally and at right angles to each other.

FIFTEENTH WEEK. Draw carefully the whole tongue from two directions.

SIXTEENTH WEEK. Draw the two most comprehensive longitudinal sections and a number of cross sections and indicate on the other drawings the approximate place of these.

GROUP III Development of the plant louse. Needed: Salt solution, alcohol, oil of cloves, balsam, glycerine jelly, a watch glass, needles in handles, slides, covers, microscope, a number of plant lice.

TWELFTH WEEK. Dissect in salt solution a full-grown plant louse, isolating the ovaries. Mount in glycerine jelly as directed under field work and examine under the microscope to see if the embryos are whole and sufficiently separated from each other and from the other tissue. Mount a good number of slides.

THIRTEENTH WEEK. Dissect as above and mount in balsam a number of slides.

FOURTEENTH WEEK. Study the slides and pick out a series of about six stages in jelly and in balsam, showing the development of the young louse. Compare Mark. Die Pflanzenlaus.

FIFTEENTH WEEK. Draw the three smaller stages, naming all the parts which can be recognized.

SIXTEENTH WEEK. Draw the older stages as above.

FIFTEENTH WEEK.

The work of this week is elective. For directions see under twelfth week.

ELECTIVE WORK.—Morphology (con.)

THIRTEENTH WEEK. The tongues stained last week are removed to fresh strong alcohol a few minutes, then to oil of cloves about two minutes, until they have become uniformly somewhat clear. They are now put into barely melted soft paraffin (50° C.) for one-half hour, then for one hour into harder (55° C.). Ladle out onto a wet cold plate of glass, so as to form thick drops with a tongue in the middle of each. After they are thoroughly cool trim into rectangular blocks and fasten one by means of a hot knife blade to the object holder of the microtome in such a position as to cut cross sections. Cut as thin as possible, adjusting the temperature of the room to the hardness and thickness of the section, so that while the sections will not wrinkle, they will stick together and form a perfect ribbon. Keep the order of every section very carefully should the ribbon break. Mount as follows: Paint a thin layer of Schallibaum's fixative on a slide. Arrange the sections in the order cut, using two slides if one is not enough. Place in the oven of the bath at 55° C. five minutes. Wash while hot with turpentine and apply the balsam and cover at once.

FOURTEENTH WEEK. Cut and mount two more sets of section longitudinally and at right angles to each other.

FIFTEENTH WEEK. Draw carefully the whole tongue from two directions.

SIXTEENTH WEEK. Draw the two most comprehensive longitudinal sections and a number of cross sections and indicate on the other drawings the approximate place of these.

GROUP III. Development of the plant house. Needed: Salt solution, alcohol, oil of cloves, balsam, glycerine jelly, a watch glass, needles in handles, slides, covers, microscope, a number of plant tissue.

SEVENTH WEEK. Dissect in salt solution a full-grown plant house, isolating the ovaries. Mount in glycerine jelly as directed under field work and examine under the microscope to see if the embryos are whole and sufficiently separated from each other and from the other tissue.

EIGHTH WEEK. Dissect as above and mount in balsam a number of slides.

NINTH WEEK. Study the slides and pick out a series of about six stages in jelly and in balsam, showing the development of the young house. Compare Mark Die Pflanzenhaare.

TENTH WEEK. Draw the three smaller stages, naming all the parts which can be recognized.

ELEVENTH WEEK. Draw the older stages as above.

SIXTEENTH WEEK.

The work of this week is elective. For directions see under twelfth week.

ELECTIVE WORK.—Morphology (con.)

GROUP IV. The cranium of the wasp. Needed: A small beaker. A wash bottle. A pair of small sharp-pointed scissors or sharp-pointed knife. A number of wasps.

TWELFTH WEEK. Put about a dozen heads to soak in the beaker, and let them macerate for two weeks. Take other specimens and carefully study the external structure, drawing from above and from before, paying particular attention to traces of nearly obliterated sutures.

THIRTEENTH WEEK. Draw and study the head very carefully from the side and from behind.

FOURTEENTH WEEK. Take the material that has been soaking, and with the wash bottle clean out the inside. Remove carefully the mouth parts and antennæ. Put the specimens all to soak again, taking them out only as needed. Take a specimen, and from the neck opening cut through the head below the eyes and antennæ. Dry and study the internal configuration of the crown, comparing it with the outside. Study several specimens.

FIFTEENTH WEEK. Cut up the side of the head from the mouth opening through the eyes, and study carefully the internal configuration of the face.

SIXTEENTH WEEK. Cut in the median line through the neck and mouth openings and study the side of the head.

GROUP V. Development of the honeybee. Needed: Two dozen three-dram vials. Two watch glasses. Two large cover glasses. A comb of brood in all stages.

TWELFTH WEEK. Examine carefully the heads and determine by their size the number of stages represented. Take a number of each, including the eggs and full-grown bees, and place each stage by itself in vials of 50 % alcohol, and after two hours change to strong alcohol. Fix another set by first treating in hot water, as directed under the second group, and puncturing in several places before putting into alcohol.


THIRTEENTH WEEK. Study the three youngest stages of both sets, studying them in alcohol in the watch glasses. Be careful that the upper side of the cover glass remains dry. Describe the stages and the changes undergone.

FOURTEENTH WEEK. Study the remaining stages to where the wing cases appear.

FIFTEENTH WEEK. Study the stages bearing wing cases.

SIXTEENTH WEEK. Study the change to the adult condition.



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